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DESIGN AND SIMULATION OF POROUS SILICON BASED GAS SENSOR

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ABSTRACT

A thin film MEMS based humidity sensor is designed & analyzed using Intellisuite CAD software. Measuring instruments for humidity usually rely on quantity measurements such as temperature, pressure, air or gas volume, etc. The main motivation behind this study is the need in the automotive, food / beverage, cosmetics, and pharmaceutical industries. Here the structure of the sensor holds a very thin film that detects the presence of gasses such as ethanol, propane, steam, hydrogen, etc. Variation of parameters such as temperature, resistance, potential difference across sensing electrodes can calculate the presence of sensing layer.

KEYWORDS: PS, Intellisuite, MEMS.

INTRODUCTION

Using Intellisuite, a thin film MEMS based humidity sensor is designed and analyzed. Humidity measuring instruments usually rely on measurements of quantities such as temperature, pressure, volume of air or gas, etc. The main motivation behind this study is the automotive, food / drink, cosmetics, and pharmaceutical needs. Here the sensor's structure holds a very thin film detecting the presence of gasses like ethanol, propane, steam, hydrogen, etc. The presence of sensing layer can be calculated by variation of parameters such as temperature, resistance, potential difference across sensing electrodes.

In each case, the sensing parameters of PS were heavily dependent on the production process. The etching solution's electrical potential and the etching time are critical steps in the production process. Also critical in the formation of porous silicon are factors such as the silicon orientation and the etching cell geometry.[3,4] The collective effect of these parameters makes it possible to achieve different PS formations. The two fast-reversible contact PS gas sensor is the most applicable example of chemical sensing PS formation. The two designs of contact are a precursor to the device examined in this report. The PS gas sensor's energy consumption is low.[5] This attribute is achieved through low-resistance ohms formed on the device's surface. Furthermore, reducing the Schottky barrier between metal and silicon resulted in the alkane group being better detected.[6] The evaluated limitations of the original design were sub-pppm at room temperature. Several other gas sensing PS structures were displayed at room temperature.

Generally speaking, the gas sensing mechanism is based on the adsorbed analyte molecules ' gas modulation effect in the PS film on the PS resistor surface.[7] Measurement of gas sensing was performed using known gas value in a controlled environment.

The characteristics of impedance and gas response of PS sensors were evaluated by measuring changes in gas injection conductance to trace target gas concentrations. By static distribution with an air-tight micro-syringe, the desired or known concentration of measuring gas was injected into the chamber. Now a customized software for recording gas sensitivity was running on a PC. The sensor data was displayed in real time on the PC screen and saved for further processing, analysis and classification on the disk.[11,12,13] The report describes gas sensing technologies that are relevant to PS and its characterization using the gas injection method and processing of signals and detailed attributes of existing technologies. The main objective of this work is to design and analyze and simulate the PS gas sensor's electrical behavior in the presence of pre-calibrated gas concentrations using Intellisuite software.

SIMULATION AND ANALYSIS

Dimensions of the porous silicon based gas sensor

In simulation with boron-implanted P-type silicon substrates (10 µcm), porous silicon (149 µcm), and metal contacts, the PS gas sensor is represented. The P-type sample is 2 cm long and 2 cm wide; porous silicon is made on p-type silicon, with a 1.2 cm x 1.2 cm area and a 525 µm thick P-type substratum. The thickness of the PS sensor varies from 10 µm to 100 µm and the electrical contact of Gold (Au) that is 1 µm thick and 1 mm x1 mm size. Figure 3.1 shows the gas sensor's 2D top view design.

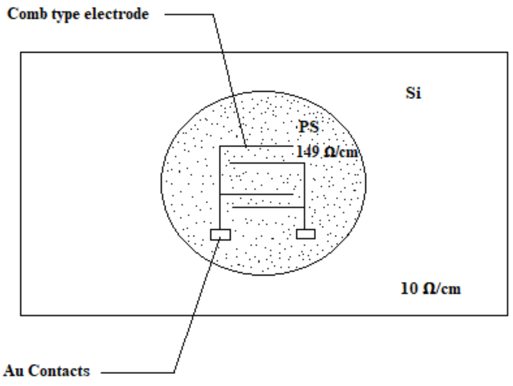

Figure 2.1 Representation of the sensor in simulation depicting top view of the sensor.

Figure 2.1 shows the top and side geometrical view of PS based gas sensor.

Simulation using Intellisuite

The following figures show the different PS sensor simulated results. Figure 2.2 & 2.3 shows respectively the surface current density distribution and the PS gas sensor's potential between the two contacts. Figure 2.2 shows that there is a huge change in current density at the junction of the metal silicon. This change in current at the interface between metal and silicon further results in the flow of surface current between the electrical contacts.

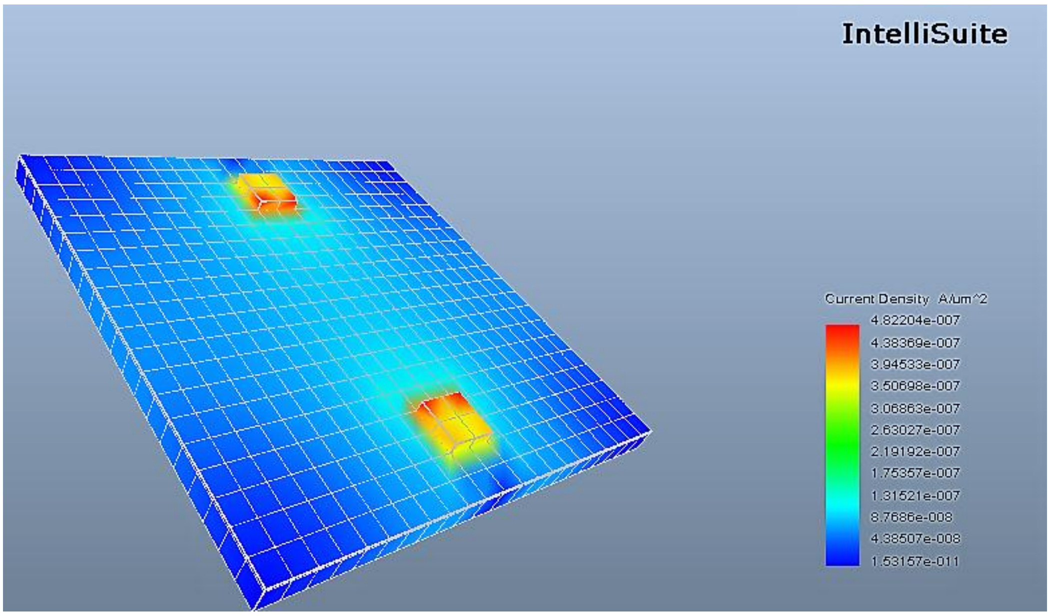

Figure 2.2: Current densty flow on the top surface of PS.

Figure 2.3 Potential differences between the contacts of the sensor.

From Figure 2.3, it is observed that there is almost very less potential flow between the two point electrodes.

RESULTS AND DISCUSSION

Resistance measurement

A resistance is the opposition to the flow of electric current by a substance. Changes of resistance are known to be resistivity by unit length, thickness, area or volume of the product.

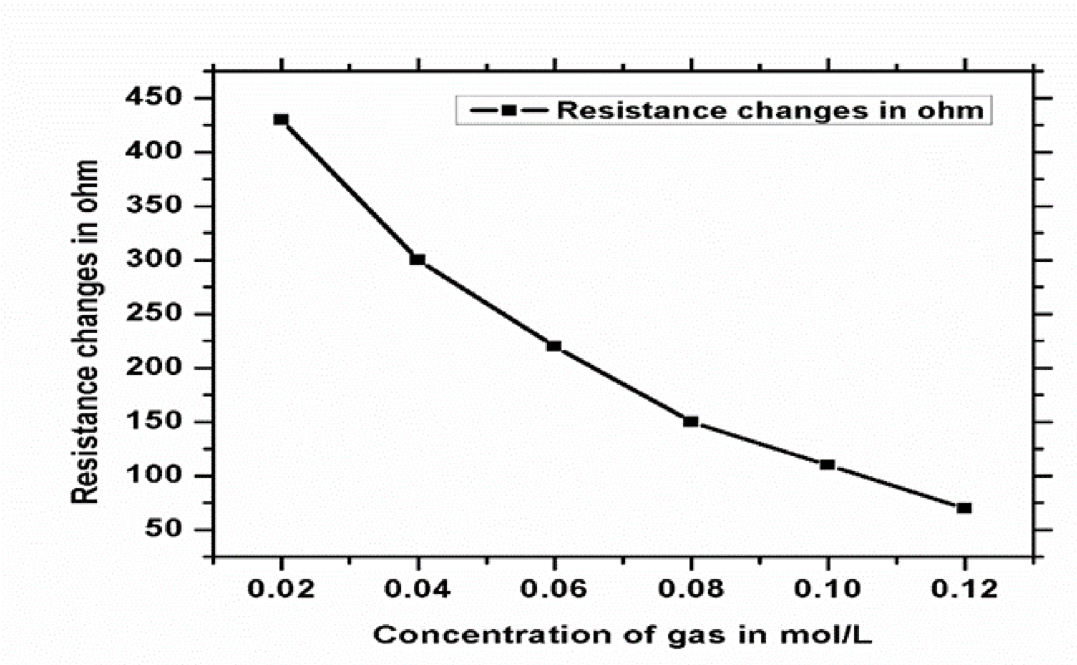

Figure 3.1: Resistance variations with ethanol concentration.

The above figure describes the relation between resistance and thickness of sensing layer for different gases concentration. Hence this shows that resistance is inversely proportional to the thickness of sensing layer.

Temperature uniformity

A temperature sensor plays an important role in many applications. For example: fabricate medical drugs, heat liquids, or clean other equipment. Figure 3.2 describes the variation of temperature across the sensor layer. The below figure shows that uniform sensing along the surface of the gas sensor ranging from 440k to 600K. layer.

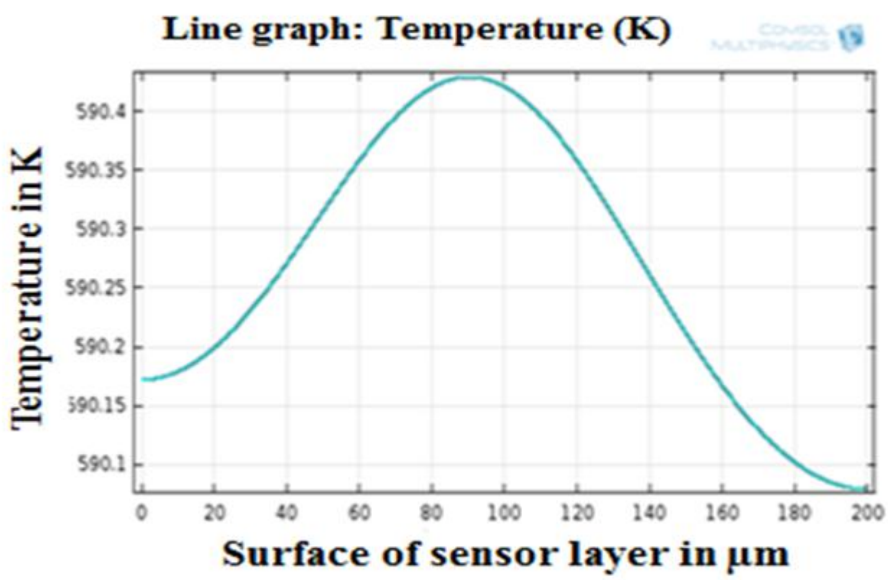

Figure 3.2: Variation of temperature across the sensor layer.

The minimum temperature is being found along the edges only uniform temperature is being recorded at the surface of the sensing The maximum temperature of the micro heater is 619.29 K.

Power loss

A power outage (also called a power cut, power failure or a blackout) is a short-term or a long-term loss of the electric power to a particular area. There are many causes of power failures in an electricity network.

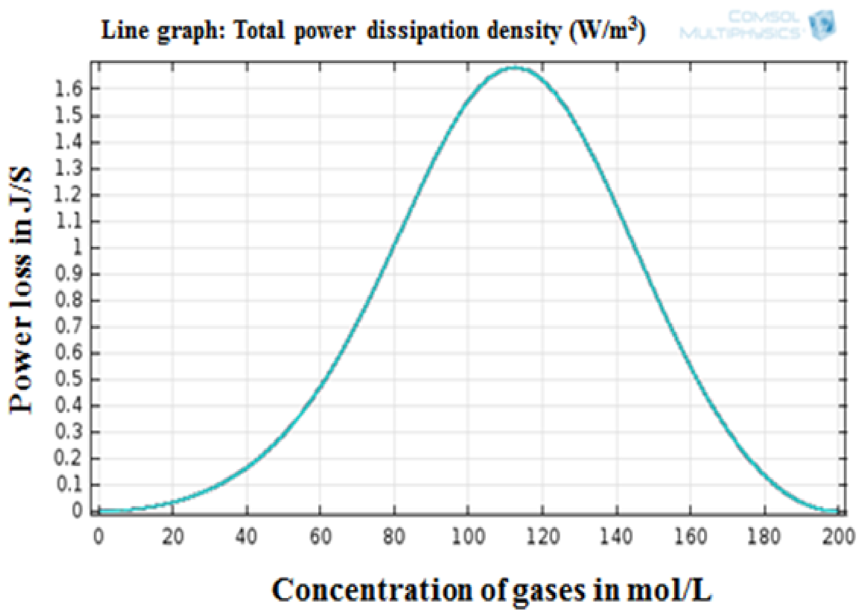

Figure 3.3: Variation of power losses for different gas concentration.

The power loss by heater is always depending upon the geometry of micro heater. Hence the above figure shows that power loss at the heater is minimum at the centre and increases sidewards while reaching at edges.

CONCLUSIONS

The electrical PS sensor behavior of VOC gas based on MEMS was characterized and the key findings are as follows:

1. The Design analysis & study of thin film MEMS based humidity sensor have been designed simulated & its results are discussed
2. We have optimized the maximum temperature, sensitivity, selectivity & reduced power consumption.
3. In future this device could be carried out for the fabrication of novel gas sensor for varying applications.

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